# ARCWIND PROJECT

# High Space and Time Surface Wind Analyses Estimated from Remotely Sensed Observations

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## Summary

This report provides an overview of surface wind analyses estimated mainly from satellite observations, over a limited oceanic area (Figure 1), including Iberian seas, south of Biscay bay, and North of Africa, and named hereafter southern ARCWIND arera. The analyses are available for a period of 10 years (2004 – 2013) at synoptic times (00h:00, 06h:00, 12h:00, and 18h:00 UTC) as 6-hourly averaged winds with over a grid map of 0.125° in latitude and longitude.

In this project, the main wind sources are derived from scatterometer wind observations. Several papers provide details about scatterometer physics, retrieval methods and processing, calibration and validation, and objective method. The readers may find some relevant references in (Bentamy et al, 2017, and Desbiolles *et al*, 2017). For more than twenty years, scatterometers on polar-orbiting satellites provide valuable information on both wind speed and direction, with

good spatial sampling over the global oceans (Bentamy *et al*, 2017). The latest scatterometers such as SeaWinds onboard the QuikSCAT satellite, ASCAT-A/B onboard METOP-A/B, and RapidScat onboard the International Space Station (ISS) provide surface winds with high spatial resolution of 12.5km.

One the main objective of ARCWIND project dealing with the characterization of wind resources, is the determination of regular high resolutions in space and time wind fields, estimated from scatterometer in combination with ancillary remotely sensed data such as radiometer winds at regional scale. Two SSM/I and SSMIS radiometers are used as ancillary data for the calculation of satellite wind fields (also named wind analyses).

The calculation of satellite wind analyses, based on the objective method described in (Bentamy et al, 2018), requires the use of numerical atmospheric model providing surface wind at regular space and time. To achieve the calculation of high resolution wind analyses, Weather Research Forecasting (WRF) model is used (Salvação et al, 2018).. The resulting surface wind analyses are estimated at synoptic times (00h:00, 06h:00, 12h:00, 18h:00 UTC), with a grid point of 0.125° in longitude and latitude over the area of interest. Figure 1 shows an example of four consecutive wind analyses.

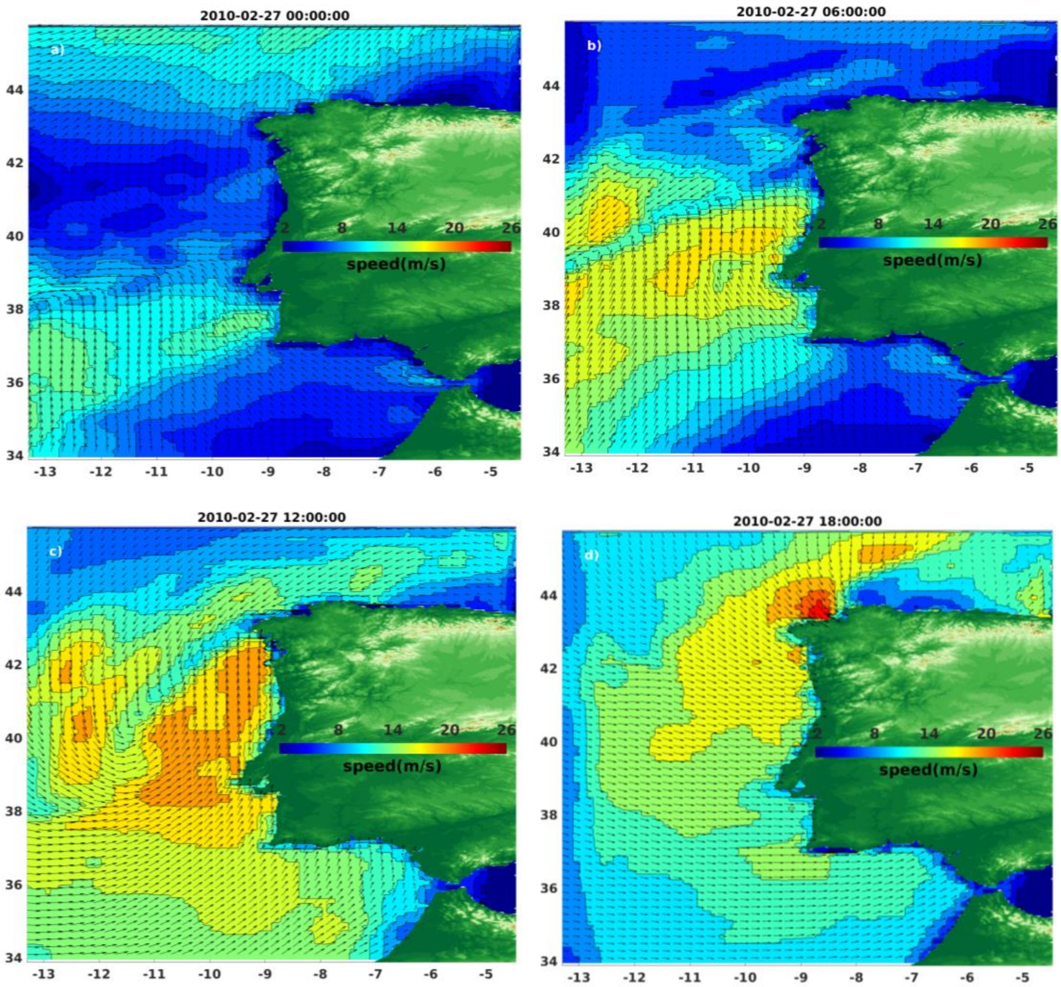


**Figure 1**: Examples of four consecutive surface wind analyses occurring on 27 February 2010 at synoptic time a)00h:00, b)06h:00, c)12h:00, and d)18h:00 UTC. Color indicates wind speed values, while black arrow indicate wind direction.

# 1 Satellite Wind Analysis Determination and Accuracy

The regular (in space and time) wind fields are estimated from reprocessed (and available) and near real time scatterometer and radiometer data in combination with WRF wind estimates (Salvação et al, 2018). They are calculated based on the use of various remotely sensed wind observations. The wind retrievals (equivalent neutral wind velocities at 10 m) from scatterometer missions since 1992 have been used to build up regular wind analyses time series of 10 year. The use of ancillary data sources such as radiometer data (SSM/I, SSMIS, WindSat) and atmospheric wind estimates (WRF) allow building a blended product available at 0.25° spatial resolution and every 6 hours from 2004 to 2013. The remotely sensed data are provided by NASA/JPL (QuikSCAT and RapidScat), EUMETSAT OSI (ASCAT-A and ASCAT-B), CNSA (HY-2A), ISRO (OceanSat-2), from Remote Sensing System (SSM/I SSMIS, and WindSat). The objective method used to achieve the calculation of high space and time resolution of wind analyses is described in (Bentamy et al, 2018).

The accuracy of blended wind fields is mainly determined through comprehensive with buoy data available over Southern ARCWIND area. Buoy data are extracted from the European Marine Observation and Data Network (EMODnet) (http://www.emodnet.eu/). Figure 2 shows wind mooring locations. The wind buoy data include wind speed at the anemometer height, wind direction (or the corresponding zonal and meridional wind components), sea surface and air temperatures, and relative humidity (or dew point). As satellite wind observations and analyses correspond to wind at 10-m above the ocean surface, the buoy winds are converted to 10-m equivalent neutral wind '(ENW) using coare3.0 parameterization (Fairall *et al*, 2003).


Figure 2: Wind buoys (from EMODNET) locations

For comparison to satellite wind analyses, all valid buoy data available within 3 hours from the epoch analysis times (00h:00, 06h:00, 12h:00, 18h:00 UTC) are arithmetically averaged. The results are referred to as 6-hourly buoy wind estimates. For comparison purpose, buoys and analysis 6-hourly data are collocated in space (<12.5km) and time. Figure 3 illustrates example of 6-hourly wind speed comparisons. It shows results associated with blended winds and with WRF estiamates. The accuracy of the wind analyses is characterized by the first statistical moments of their differences with collocated buoy data (Table 1). The results shown in Table 1 rely on collocated data occurring in offshore and nearshore areas. They also estimated for all wind conditions, including low (<3m/s) and high (>15m/s) wind conditions.

Table 1: Statistical comparison results of collocated 6-hourly buoy and satellite, and buoy and WRF, 10m wind speed and the related wind components. They are estimated for the period (2004 - 2013). Bias is defined as the mean difference between buoy and blended winds (in this order). STD, bs, and ρ indicate the standard deviation, regression symmetrical coefficient, and scalar correlation coefficient, respectively.

| | Length | Bias (m/s) | STD (m/s) | bs | ρ |
|---|---|---|---|---|---|
| **Wind Speed** | | | | | |
| Satellite | 58696 | 0.34 | 1.19 | 0.95 | 0.95 |
| WRF | | 0.44 | 1.63 | 0.98 | 0.91 |
| **Zonal Wind Component** | | | | | |
| Satellite | 57840 | 0.17 | 1.88 | 1.13 | 0.93 |
| WRF | | 0.20 | 1.95 | 1.16 | 0.93 |
| **Meridional Wind Component** | | | | | |
| Satellite | 58185 | -0.05 | 2.10 | 1.10 | 0.91 |
| WRF | | -0.07 | 2.18 | 1.10 | 0.90 |

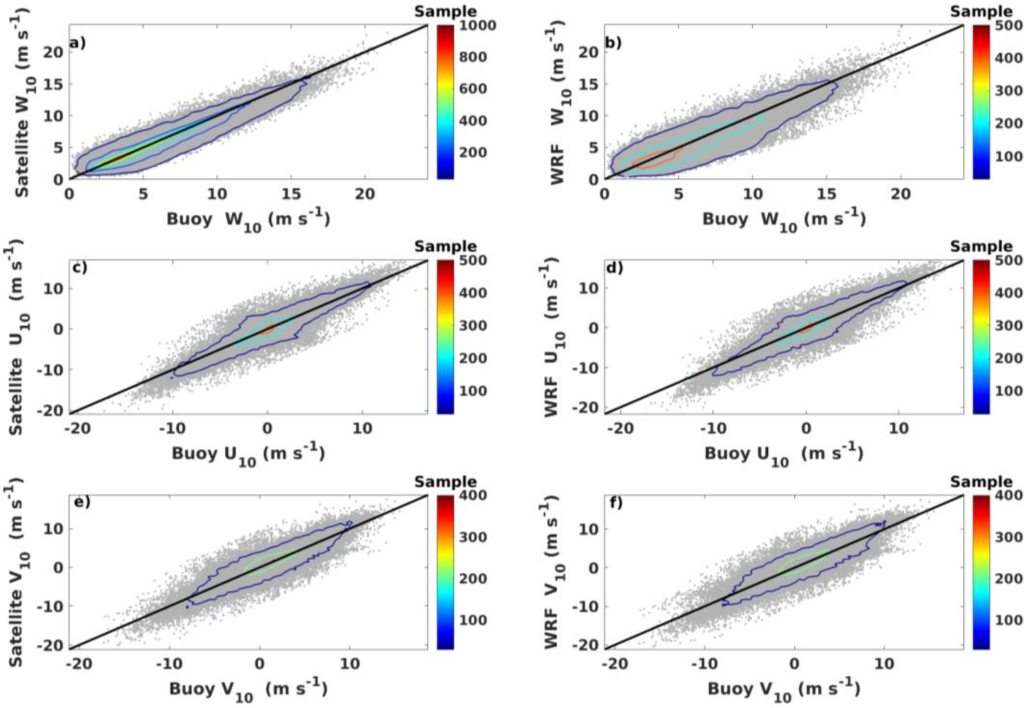


Figure 3: Comparisons of 6-hourly 10m wind speed ( a) and b)), zonal wind component ( c) and d)), and meridional wind component ( e) and f))and from buoys and satellite analyses (left panel) and WRF (right panel), determined from collocated data occurring during the whole study period 2004 – 2013. Black lines indicate perfect lines ($1^{st}$ bissectrice).

## 1. Data and File description

Time series of satellite wind analyses, estimated from 1 January 2004 through 31 December 2013, account for 12480 files. Most of missed expected analyses (about 14.5%) rely on missed WRF data. Each file is associated to 6-hourly analysis over the southern basin of ARCWIND area. Their format is NetDCF 4.0.

The file name formats are :

ARCWIND_SatelliteWind_Analyses_12km6h_YYYYMMDDHH.nc

Where YYYY, MM, DD, and HH are year, month, day, and hour of analysis.

**Example of wind file**

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netcdf ARCWIND_SatelliteWind_Analyses_12km6h_2004010106 {
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        dimtime = 1 ;
        dimdepth = 1 ;
        dimlatitude = 97 ;
        dimlongitude = 88 ;
variables:
        float time(dimtime) ;
                time:long_name = "time" ;
                time:Units = "hours since 1900-01-01 00:00:0" ;
                time:valid_min = 911646.f ;
                time:valid_max = 911646.f ;
                time:axis = "T" ;
        float depth(dimdepth) ;
                depth:long_name = "depth" ;
                depth:Units = "m" ;
                depth:valid_min = 10. ;
                depth:valid_max = 10. ;
                depth:axis = "up" ;
        float latitude(dimlatitude) ;
                latitude:long_name = "latitude" ;
                latitude:Units = "degrees_north" ;
                latitude:valid_min = 34.0625f ;
                latitude:valid_max = 46.0625f ;
                latitude:axis = "Y" ;
        float longitude(dimlongitude) ;
                longitude:long_name = "longitude" ;
                longitude:Units = "degrees_east" ;
                longitude:valid_min = -14.9375f ;
```

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longitude:valid_max = -3.9375f ;
longitude:axis = "X" ;
short wind_speed(dimtime, dimdepth, dimlongitude, dimlatitude) ;
wind_speed:long_name = "wind speed" ;
wind_speed:Units = "m/s" ;
wind_speed:scale_factor = 0.01 ;
wind_speed:add_offset = 0. ;
wind_speed:valid_min = 0s ;
wind_speed:valid_max = 6000s ;
wind_speed:_FillValue = -32768s ;
short eastward_wind(dimtime, dimdepth, dimlongitude, dimlatitude) ;
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eastward_wind:Units = "m/s" ;
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eastward_wind:add_offset = 0. ;
eastward_wind:valid_min = -6000s ;
eastward_wind:valid_max = 6000s ;
eastward_wind:_FillValue = -32768s ;
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northward_wind:long_name = "northward wind speed" ;
northward_wind:Units = "m/s" ;
northward_wind:scale_factor = 0.01 ;
northward_wind:add_offset = 0. ;
northward_wind:valid_min = -6000s ;
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northward_wind:_FillValue = -32768s ;
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land_ice_mask:long_name = "flag - 0:ocean - 1:earth/ice" ;
land_ice_mask:Units = "1" ;
land_ice_mask:scale_factor = 1. ;
```

```
        land_ice_mask:add_offset = 0. ;
        land_ice_mask:valid_min = 0b ;
        land_ice_mask:valid_max = 1b ;
        land_ice_mask:_FillValue = -128b ;
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        wind_speed_rms:long_name = "wind speed root mean square" ;
        wind_speed_rms:Units = "m/s" ;
        wind_speed_rms:scale_factor = 0.1 ;
        wind_speed_rms:add_offset = 0. ;
        wind_speed_rms:valid_min = 0b ;
        wind_speed_rms:valid_max = 100b ;
        wind_speed_rms:_FillValue = -128b ;
short eastward_wind_rms(dimtime, dimdepth, dimlongitude, dimlatitude) ;
        eastward_wind_rms:long_name = "eastward wind speed root mean squar" ;
        eastward_wind_rms:Units = "m/s" ;
        eastward_wind_rms:scale_factor = 0.1 ;
        eastward_wind_rms:add_offset = 0. ;
        eastward_wind_rms:valid_min = 0b ;
        eastward_wind_rms:valid_max = 100b ;
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short northward_wind_rms(dimtime, dimdepth, dimlongitude, dimlatitude) ;
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        northward_wind_rms:scale_factor = 0.1 ;
        northward_wind_rms:add_offset = 0. ;
        northward_wind_rms:valid_min = 0b ;
        northward_wind_rms:valid_max = 100b ;
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short sampling_length(dimtime, dimdepth, dimlongitude, dimlatitude) ;
        sampling_length:long_name = "sampling length" ;
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// global attributes:
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		:references = "e.g. See  (Bentamy et al, 2019)" ;
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		:stop_time = "06:00:00" ;
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		:westernmost_longitude = -14.9375f ;
		:grid_resolution = "0.125 degree" ;
		:file_quality_index = 0s ;
}
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## References


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